Resonance Production in Minimum bias and Jet events at CDF (1.96TeV)

K_s^0, $K^{*+/-}$ (892) , ϕ^0 (1020), Λ, Ξ, Ω

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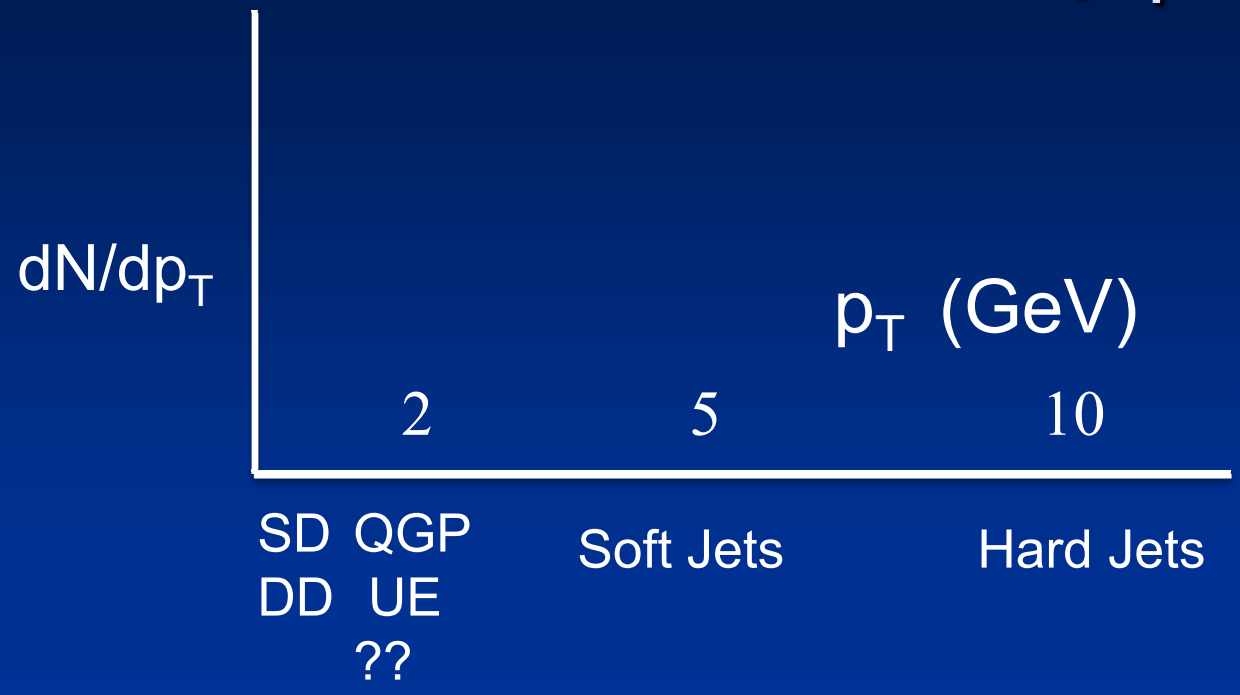
Introduction

The goal of this analysis is to obtain the p_T spectrum of strange resonances, Λ, Ξ, Ω, K_s^0, $K^{*+/-}(892)$, $\phi^0(1020)$, in an effort to understand the particle production processes in the soft QCD region.

- Using minimum bias events to study these particle up to ~10 GeV/c p_T
- Using jet events, study the transition region to see the effect of jets in p_T.
- Study of particle contents in jets as a function of jet E_T is the first time using jets from hadron colliders.

- Comparison with PYTHIA (6.327) and Herwig (6.510)

In terms of p_T

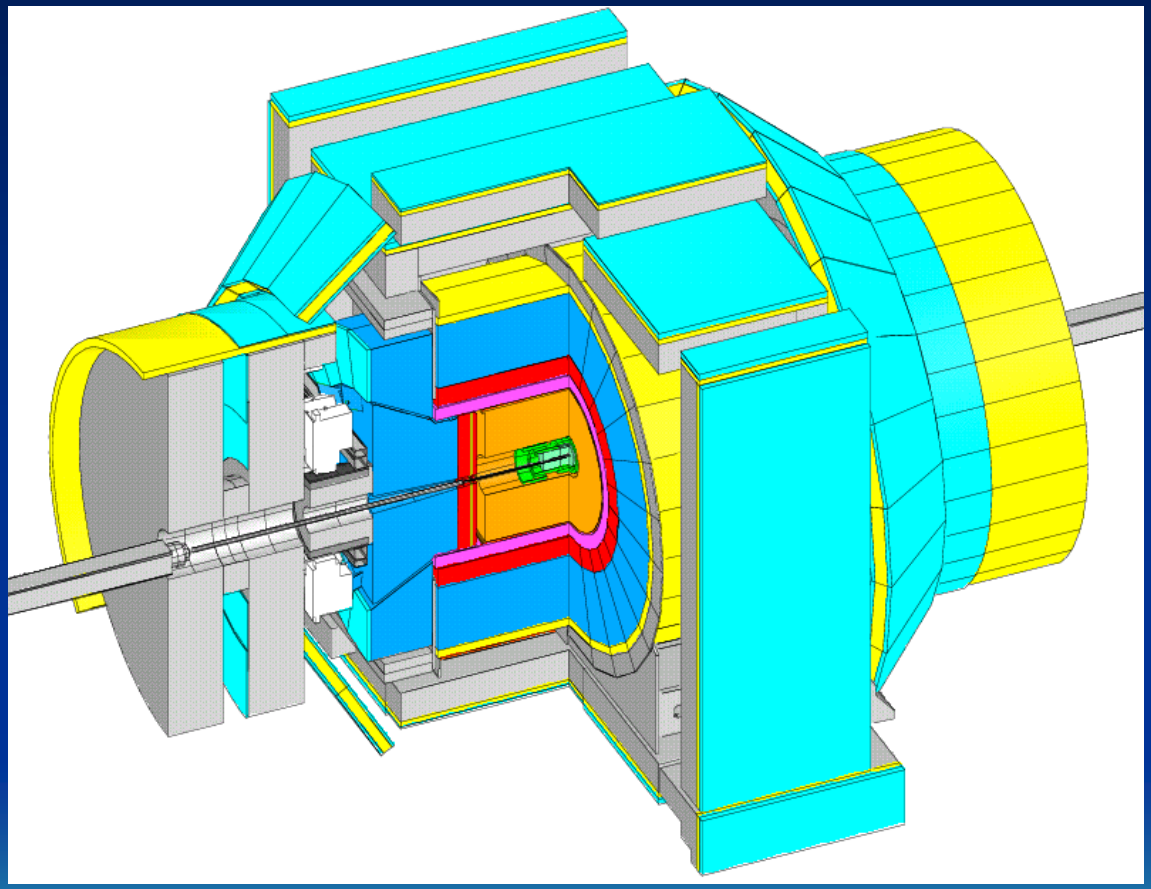


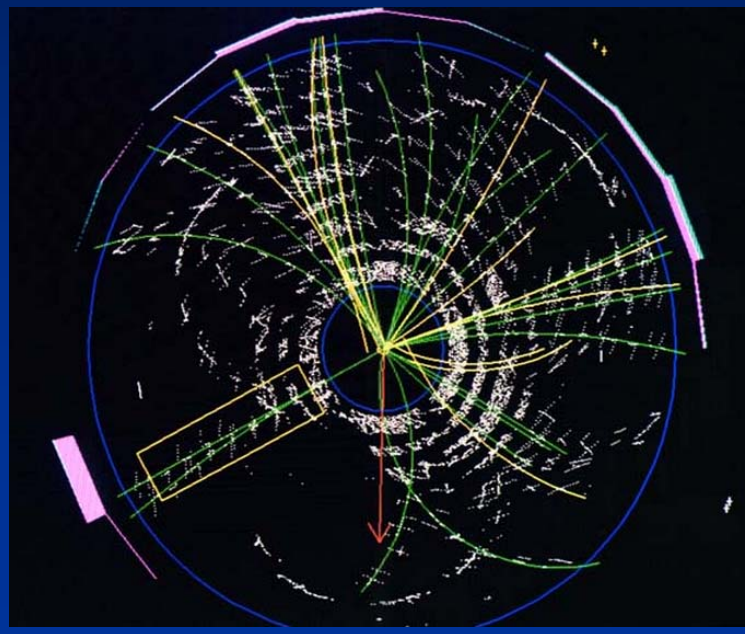
Decay modes

- $\Lambda \to p\pi$
- $\Xi \to \Lambda\pi$
- $\Omega \to \Lambda K$

- $K_S \to \pi\pi$
- $K^* \to K_S\pi$
- $\varphi^0 \to KK$

CDF detector





Data

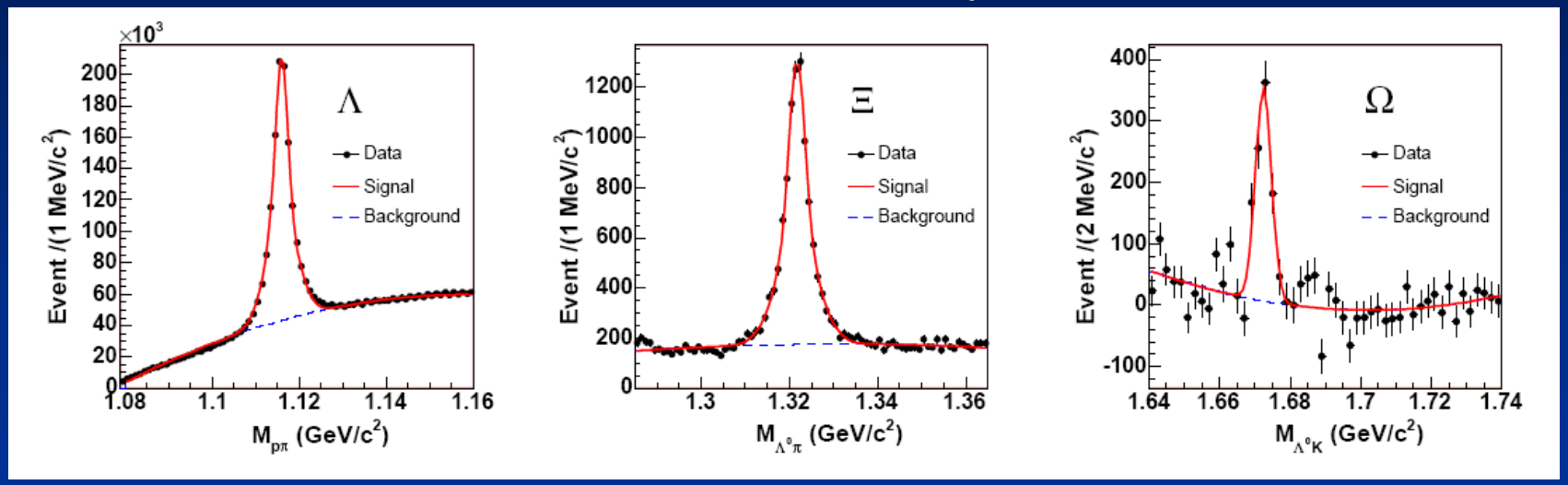
- Min-biased trigger. There are about 100 million events
- Jet data – 20, 50, 75 and 100 GeV jet E_T trigger , about 30 million jets
- MC data – PYTHIA/Herwig

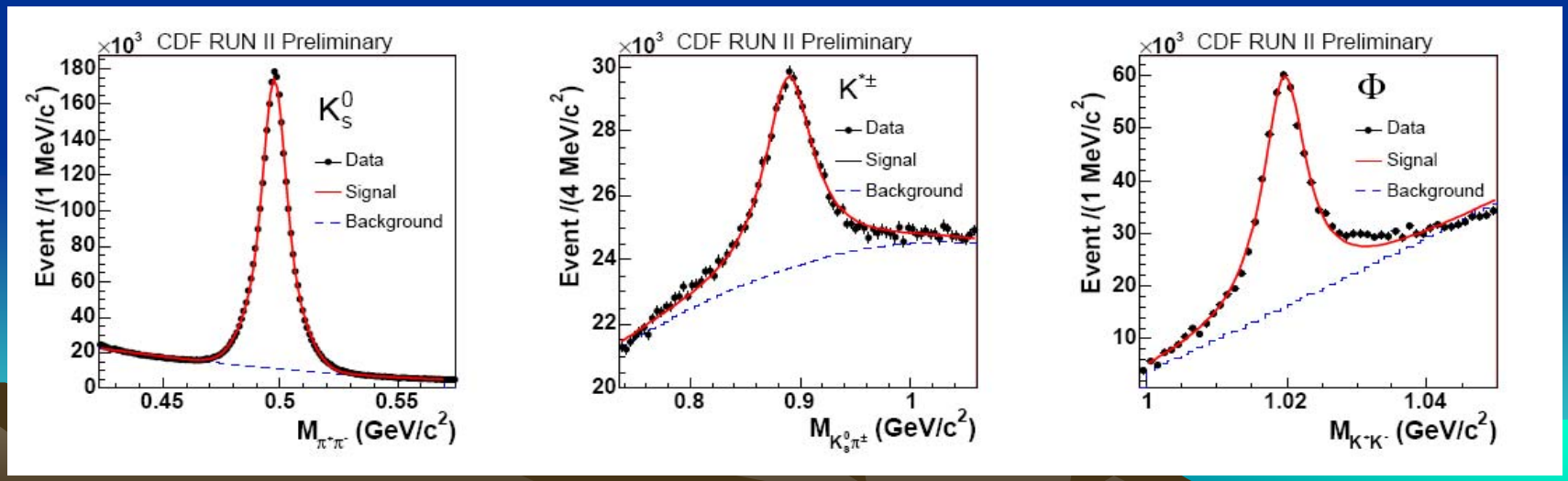
Reconstruction

- For long lived particles (K_s, Λ): match two tracks in 3D and trace back to vertex and require it is from the event vertex.
- Ξ, Ω : combine Λ with a track (π, K)
- K* :combine with K_s with a track (π)
- φ : combine two tracks at the vertex (KK)
- No TOF or dE/dx information is used

Reconstructed Resonance from Minimum bias Events

CDF RUNII Preliminary



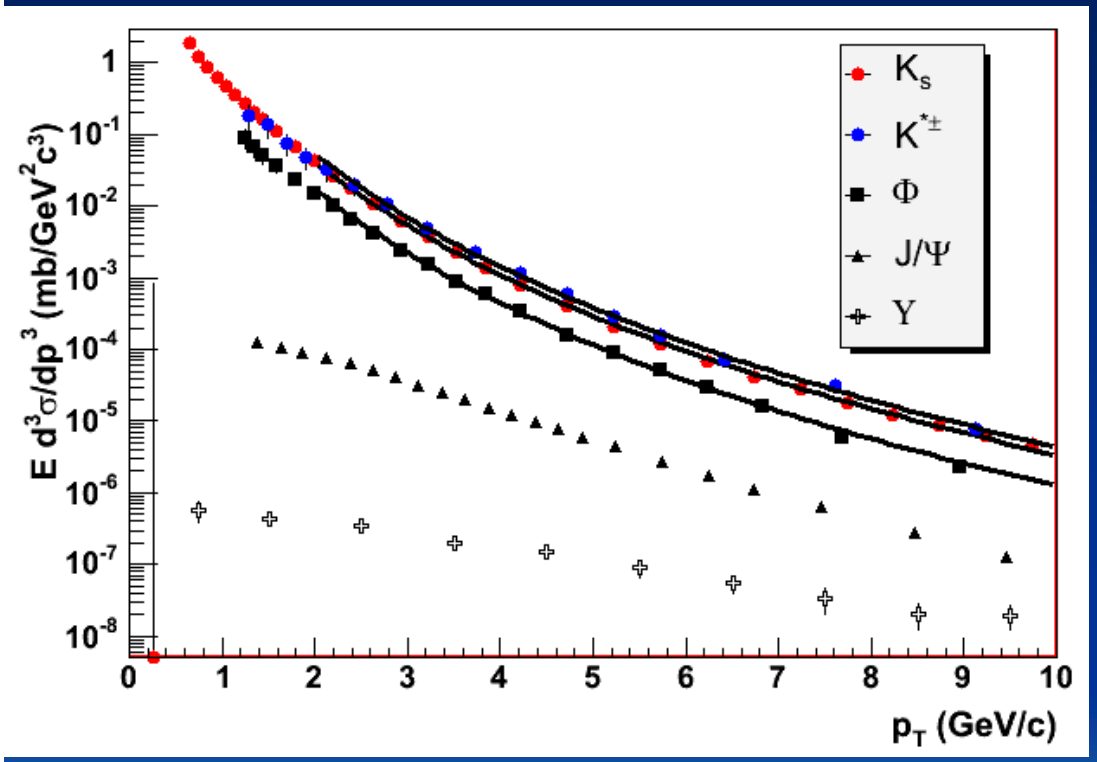


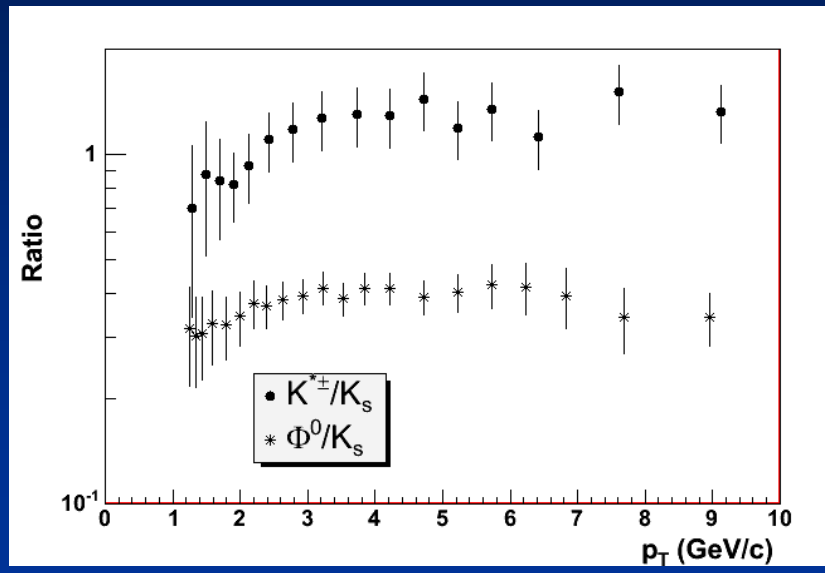
Getting the p_T plots

- The invariant mass distributions are divided into many p_T intervals (and E_T intervals in case of jet events)
- The invariant mass plots are fitted with a Gaussian (or BW, or BW convoluted with Gaussian) for the signal and third degree polynomial for the background
- The number of resonances as a function of p_T is obtained by subtracting the background.
- The numbers are acceptance corrected

Invariant cross section & Ratios

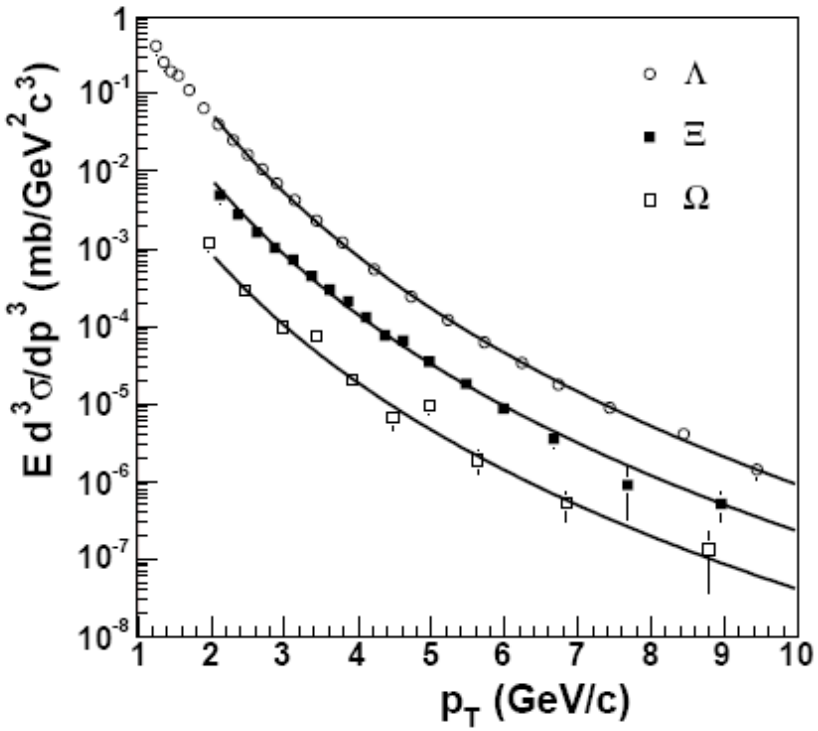
CDF RUNII Preliminary

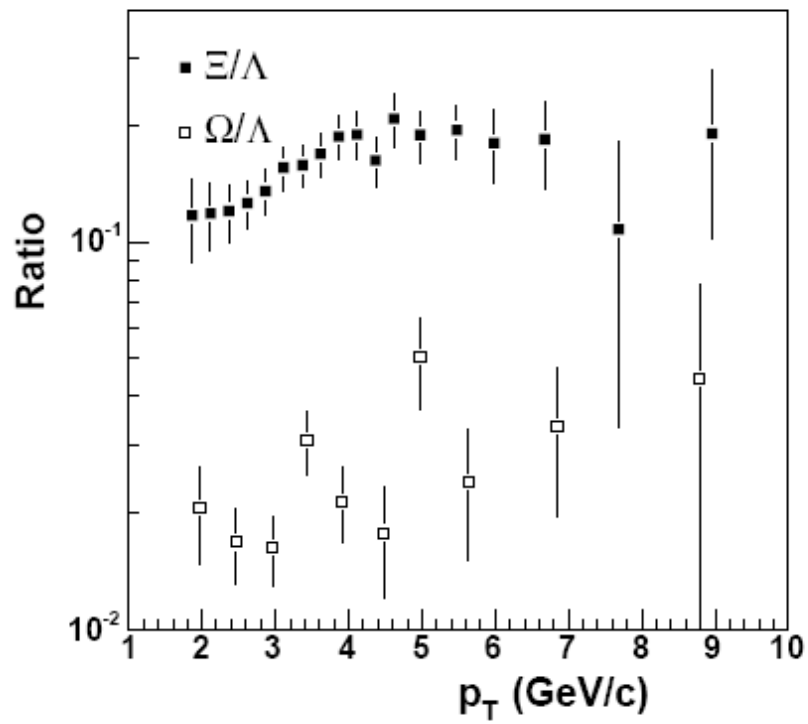




Invariant cross section & Ratios

CDF RUNII Preliminary





Fit to $A(p_0^n)/(p_T+p_0)^n$ p_0 =1.3

CDF RUNII Preliminary

Fit Parameter (units)	K_s^0	$K^{*\pm}$	ϕ^0
A (mb/GeV$^2c^3$)	47.7 ± 6.1	57.4 ± 13.5	22.3 ± 2.55
p_0 (GeV/c)	1.3	1.3	1.3
n	7.65 ± 0.08	7.60 ± 0.19	7.80 ± 0.80
χ^2/dof	6.0/17	3.9/10	14.0/13

Parameter (units)	K_S^0 [25]	Λ^0	$\Xi^\pm$	$\Omega^\pm$
A (mb/GeV$^2c^3$)	45 ± 9	210 ± 25	14.9 ± 2.5	1.50 ± 0.75
p_0 (GeV/c)	1.3	1.3	1.3	1.3
n	7.7 ± 0.2	8.81 ± 0.08	8.26 ± 0.12	8.06 ± 0.34
χ^2/dof	8.1/11	5.7/15	15.8/15	10.5/7

Fit to $B\exp(-bp_T)$

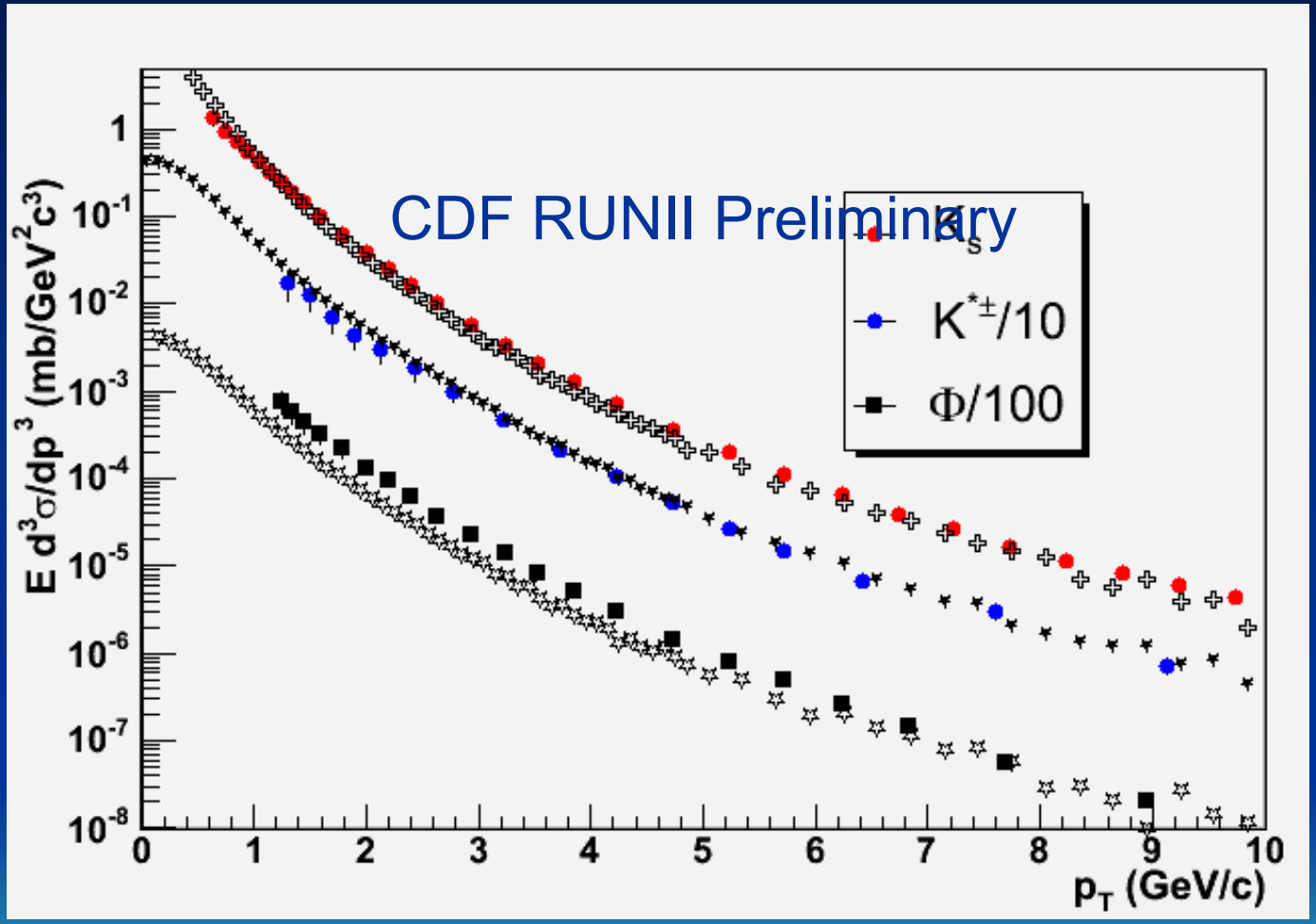
CDF RUN II Preliminary

Fit Parameter (units)	K_s^0	K_s^0	K_s^0	$K^{*\pm}$	ϕ^0
p_T range (GeV/c)	[0.6, 1.5]	[0.6, 2.5]	[1.2, 2.5]	[1.2, 2.5]	[1.2, 2.5]
B (mb/GeV$^2c^3$)	9.9 ± 2.4	6.20 ± 0.80	4.75 ± 0.92	1.70 ± 1.203	1.14 ± 0.40
b (GeV^{-1}c)	3.02 ± 0.20	2.60 ± 0.08	2.41 ± 0.10	2.01 ± 0.35	2.20 ± 0.18
χ^2/dof	1.0/9	7.2/12	0.7/6	0.8/4	0.3/7

Fit Parameter (units)	Λ^0	Λ^0	$\Xi^\pm$	$\Omega^\pm$
	$p_T \in [1.2, 2.5]$	$p_T \in [1.2, 4]$	$p_T \in [1.5, 4]$	$p_T \in [2, 4]$
B (mb/GeV$^2c^3$)	4.68 ± 1.04	3.16 ± 0.35	0.16 ± 0.043	0.024 ± 0.011
b (GeV^{-1}c)	2.30 ± 0.12	2.10 ± 0.04	1.75 ± 0.08	1.80 ± 0.19
χ^2/dof	1.0/7	7.2/12	4.0/8	6.3/3

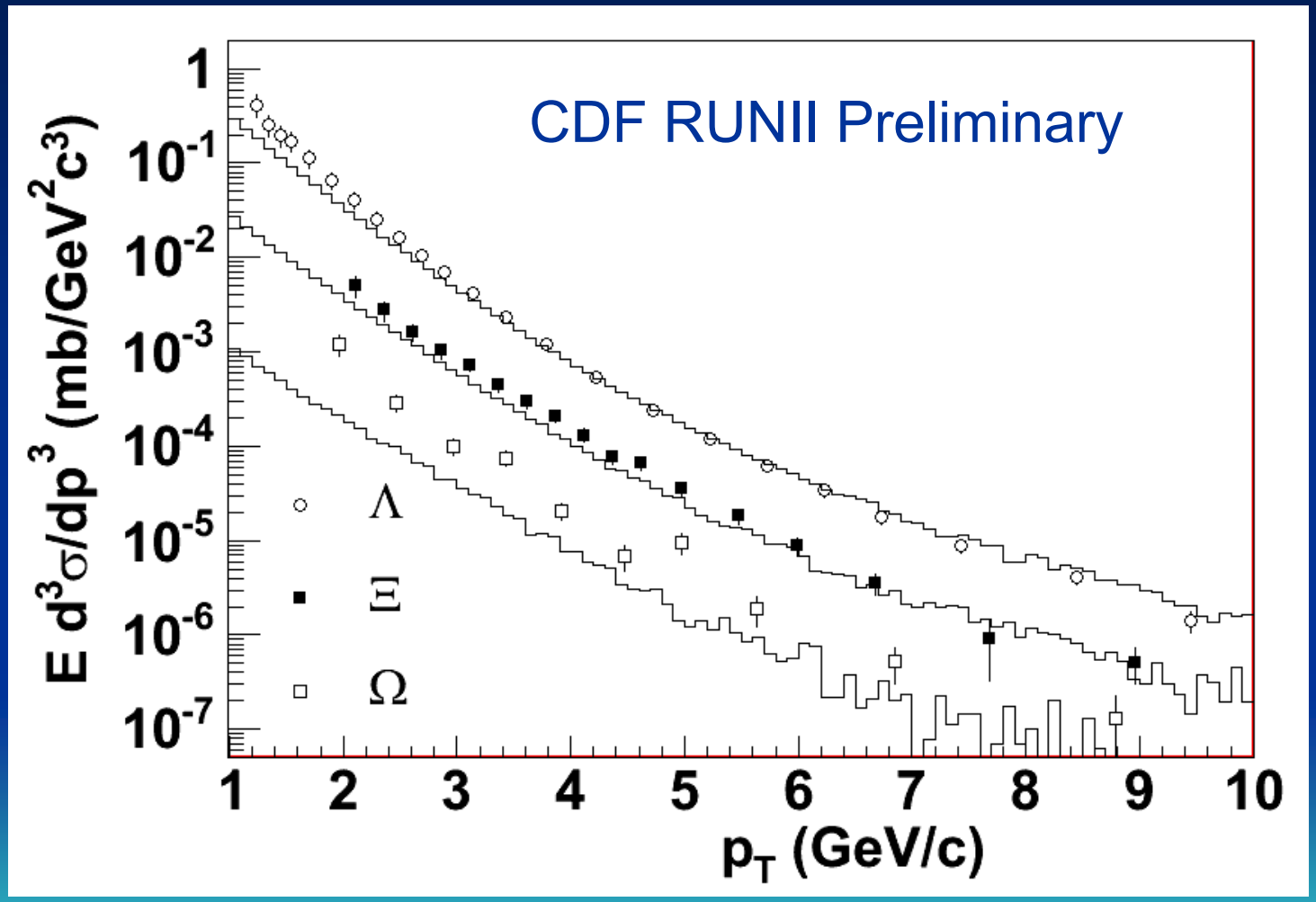
$\langle p_T \rangle = 2/b$

Pythia comparison



Parameters : Best fit to e^+e^- data at Ecm = Z^0

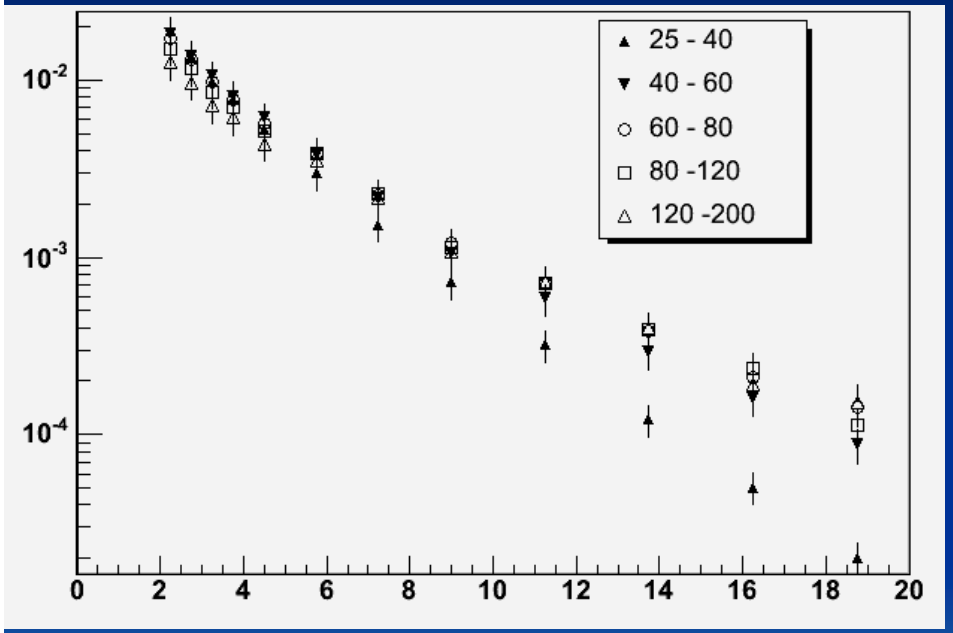
Physics Reports 291 (1997) 107-217

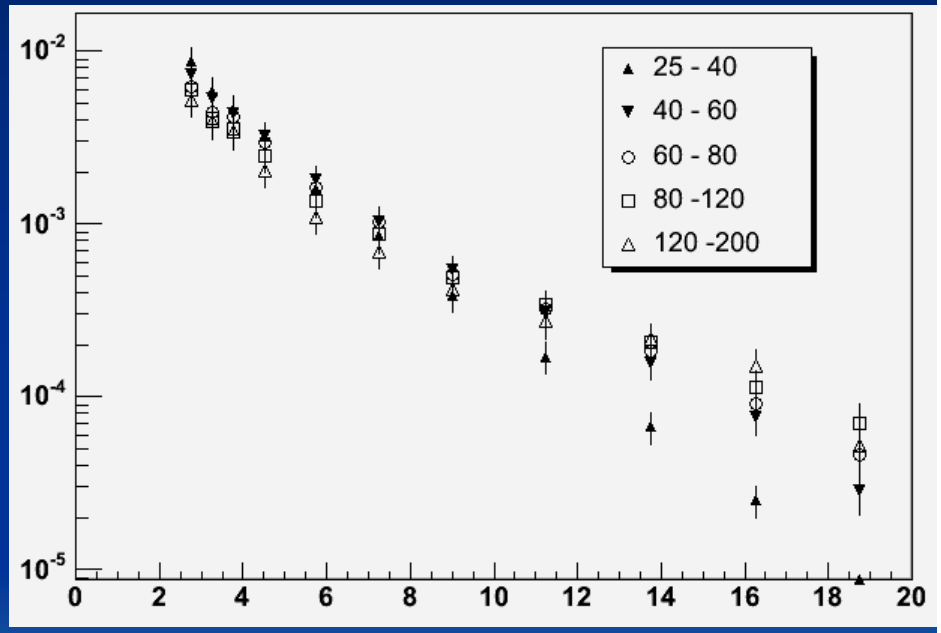


Parameters : Best fit to e^+e^- data at Ecm = Z^0

$1/N_{jet}\, dN/(p_T dp_T)$

K_S CDF RUNII Preliminary Λ

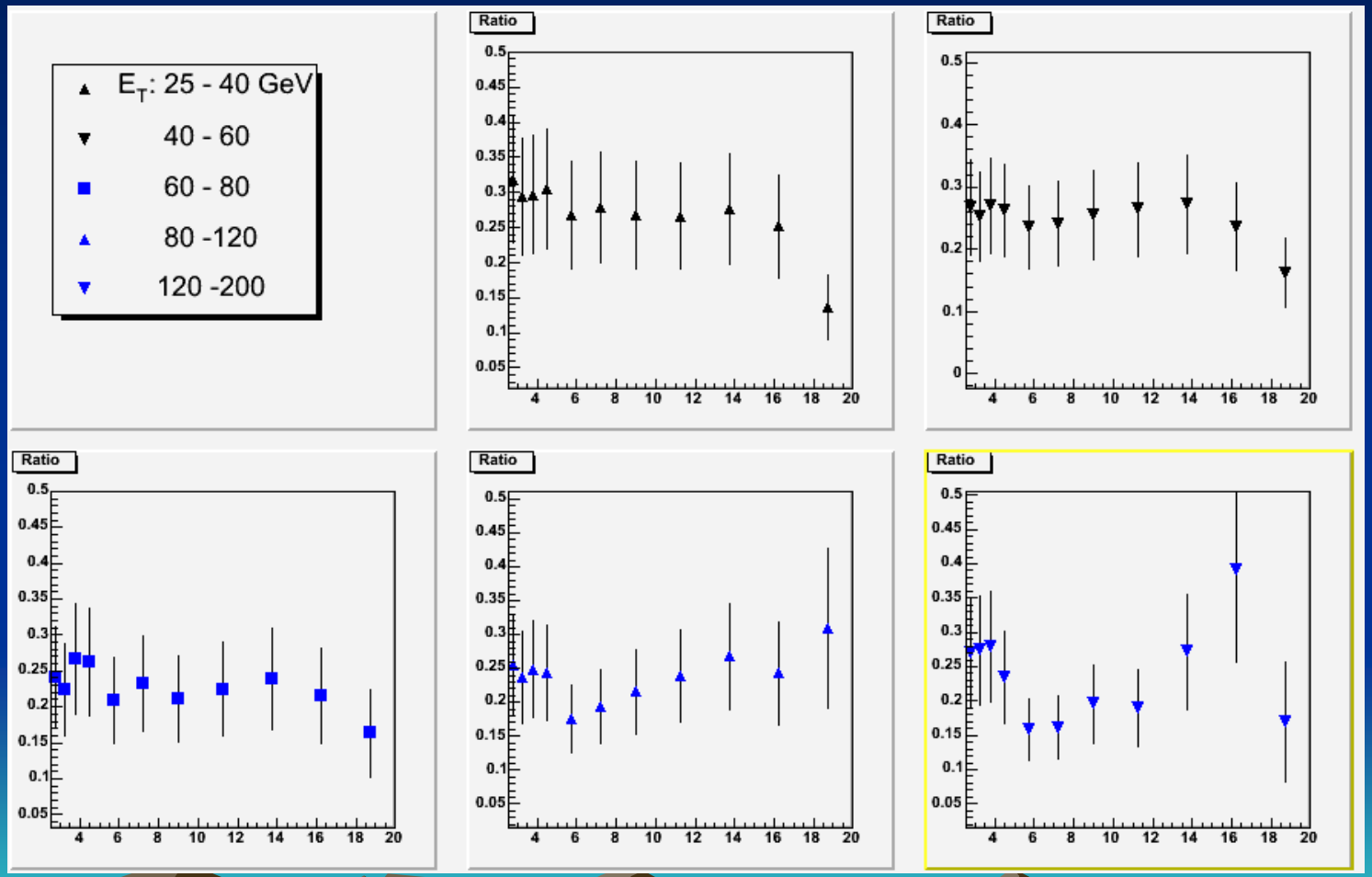




p_T (GeV/c)

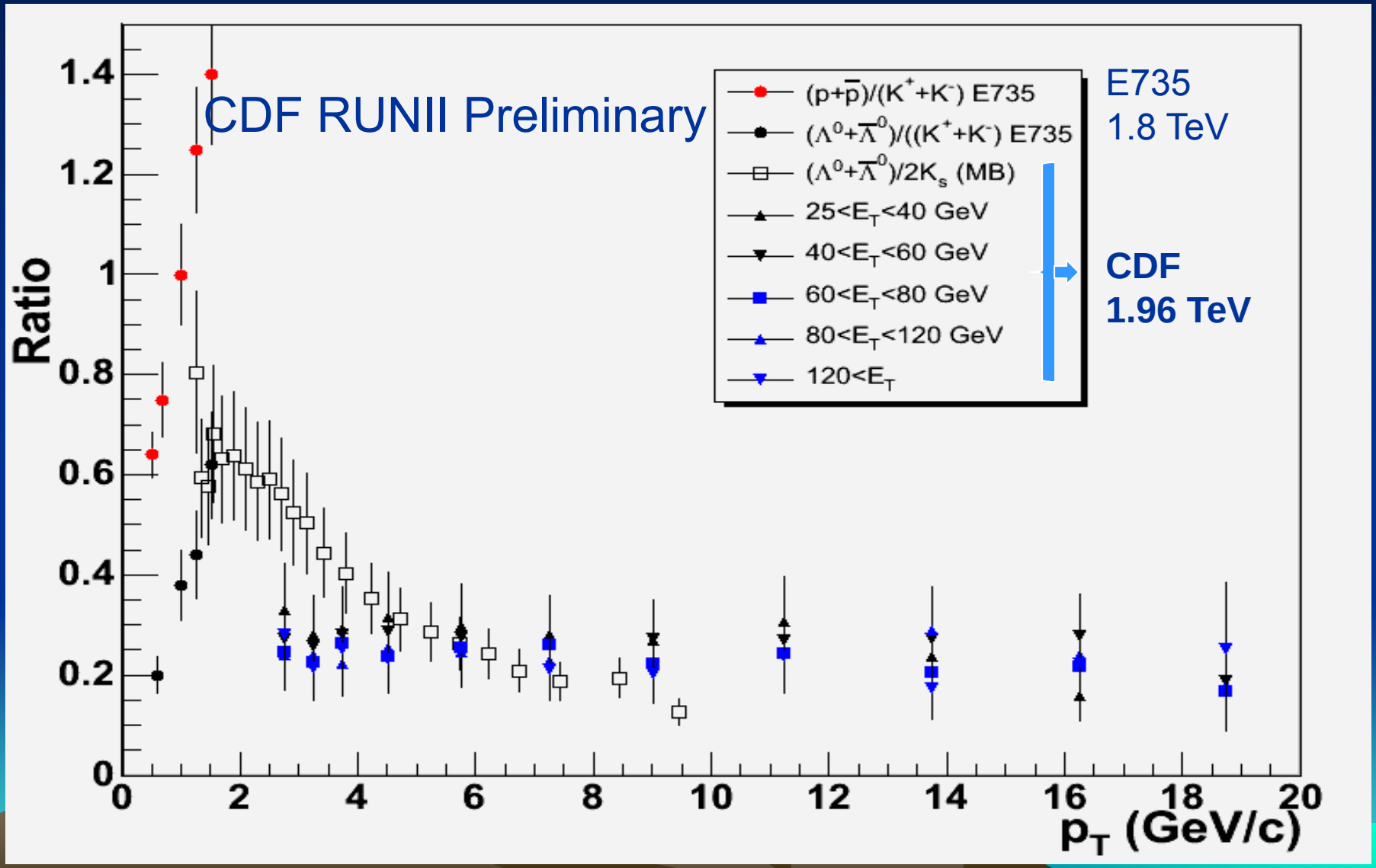
$(\Lambda+\bar{\Lambda})/\ 2K_S$

CDF RUNII Preliminary



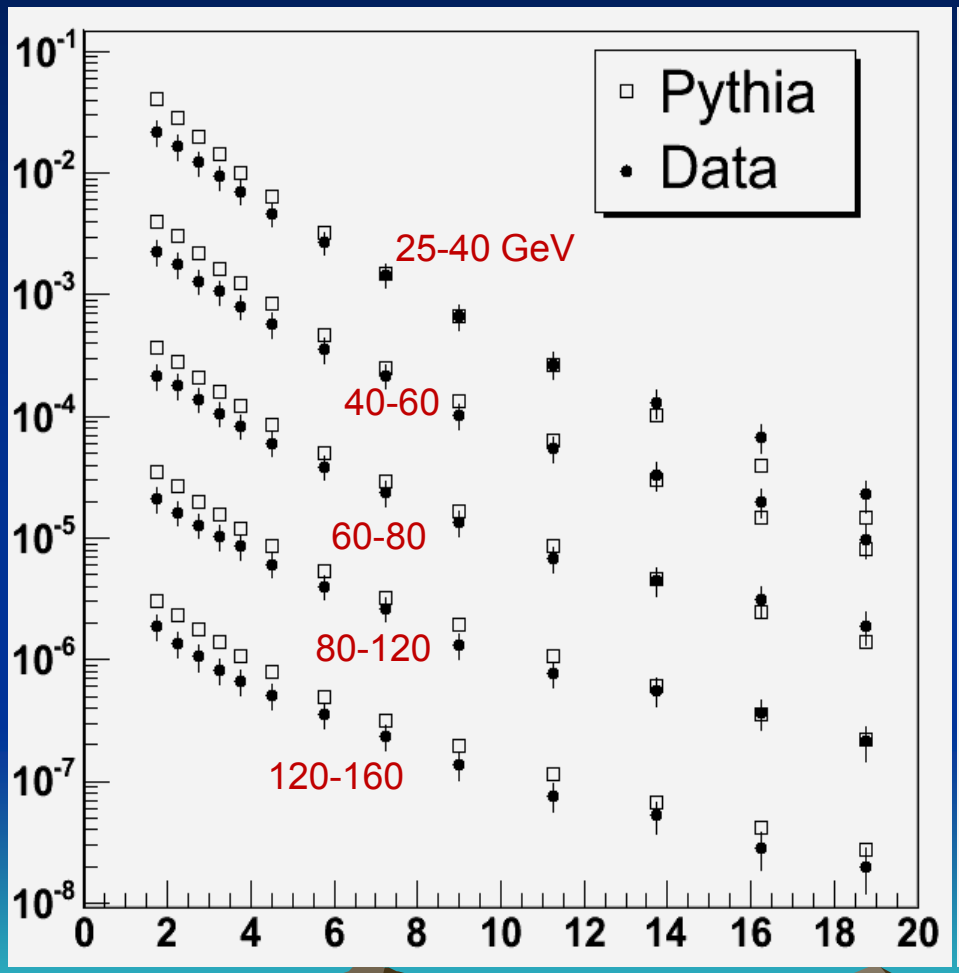
p_T (GeV/c)

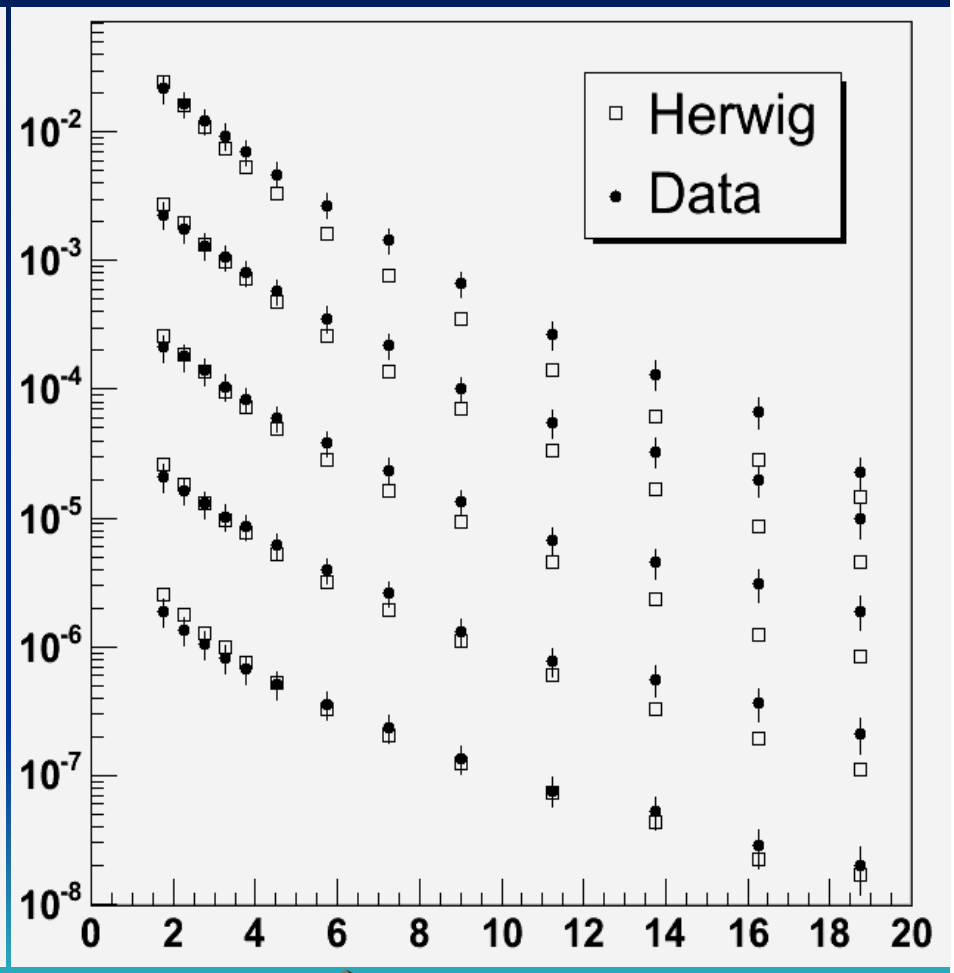
Putting together (Λ/2Ks ratio)



$1/N_{jet}\, dN_{Ks}/(p_T dp_T)$ ($\Delta R<0.5$)

CDF RUNII Preliminary

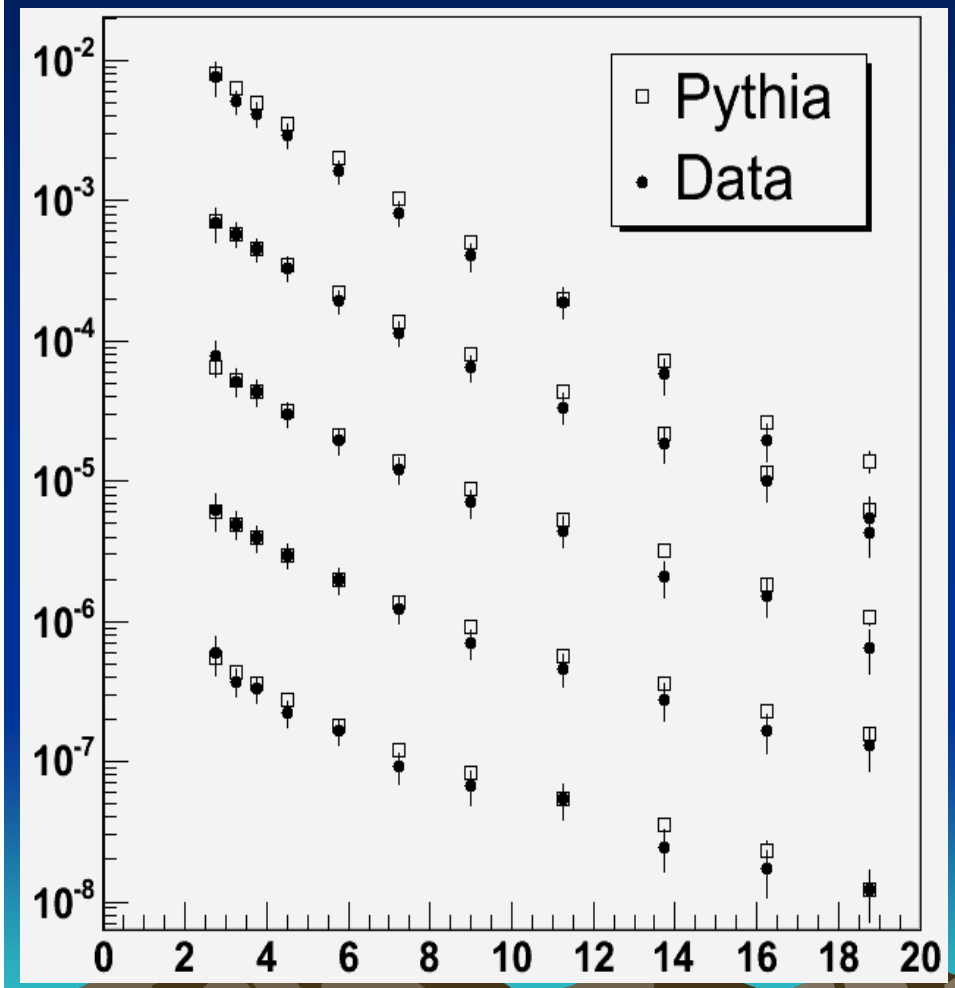


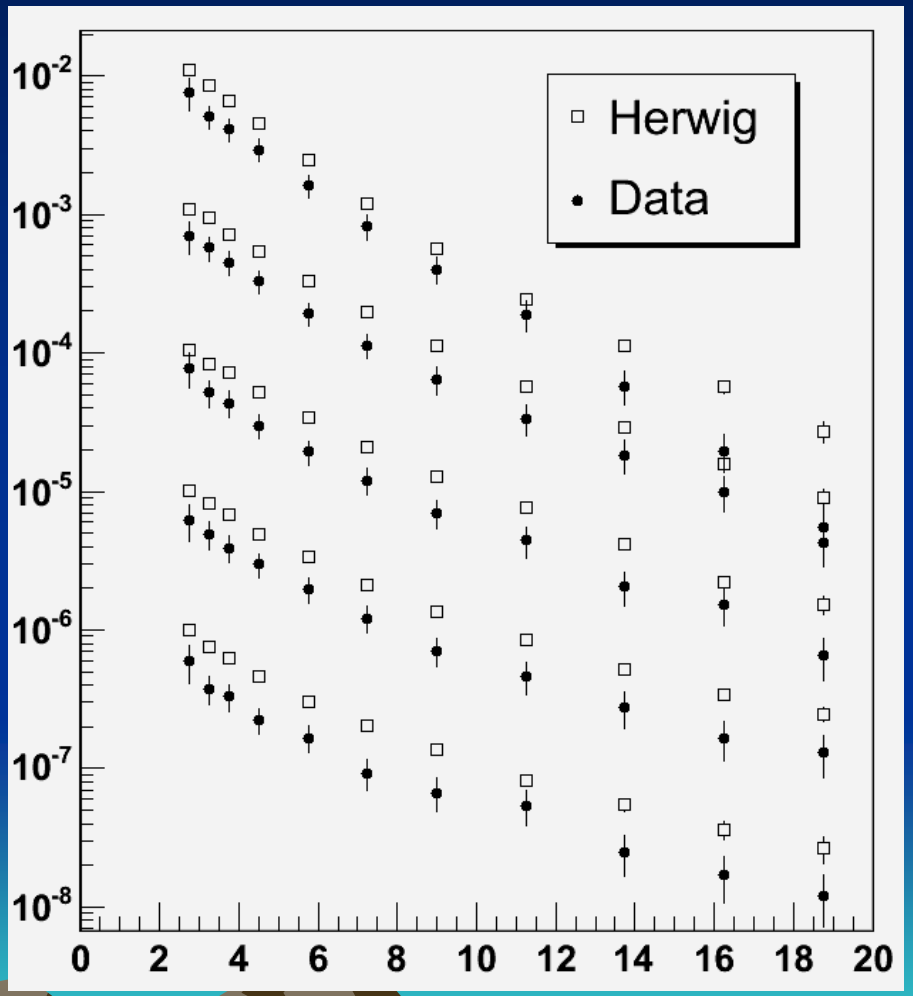


p_T (GeV/c)

$1/N_{jet}\, dN_{\Lambda+\bar{\Lambda}}/(p_T dp_T)\ (\Delta R<0.5)$

CDF RUNII Preliminary





p_T (GeV/c)

Summary

- Extensive resonance production study with minimum bias events upto p_T=10 GeV
  - Presented ratio of K^*/K_S, φ/K_S, Ξ/Λ, Ω/Λ, Λ/K_S
  - Compared with Pythia – needs more tuning
- Ks & Λ production in jets upto p_T = 20 GeV as a function of Jet E_T upto E_T = 160 GeV– first time in hadron colliders
  - $\Lambda/2K_S$ ratio ~0.25 for all E_T
  - K_S per jet ~ 0.3, Λ per jet ~ 0.15
  - Compared with Pythia, and Herwig – need more tuning

Back Ups

Differential p_T Cross Section : Min-bias Events

- $Ed\sigma/dp^3 = d^3\sigma/d\phi dy p_T dp_T$

  $d\phi = 2\pi$, and $dy = 4$

  $=[44mb/N_{event}/8\pi]\ \Delta N/Ap_T\Delta p_T$

  ΔN: number of resonances in Δp_T

  A: acceptance

  44 mb : our estimated triggered cross section

Differential P_T distribution : Jet Events

- $1/N_{jet}\, dN/(p_T dp_T) = 1/N_{jet}\, \Delta N/(A p_T \Delta p_T)$

  N_{jet} : number of jets in a E_T inerval

  ΔN: number of resonances in N_{jet} and in Δp_T

Number of K_S, $(\Lambda+\bar{\Lambda})$ per Jet ($\Delta R<0.5$)

exponential or power law extrapolation to p_T = 0 GeV

CDF RUNII Preliminary

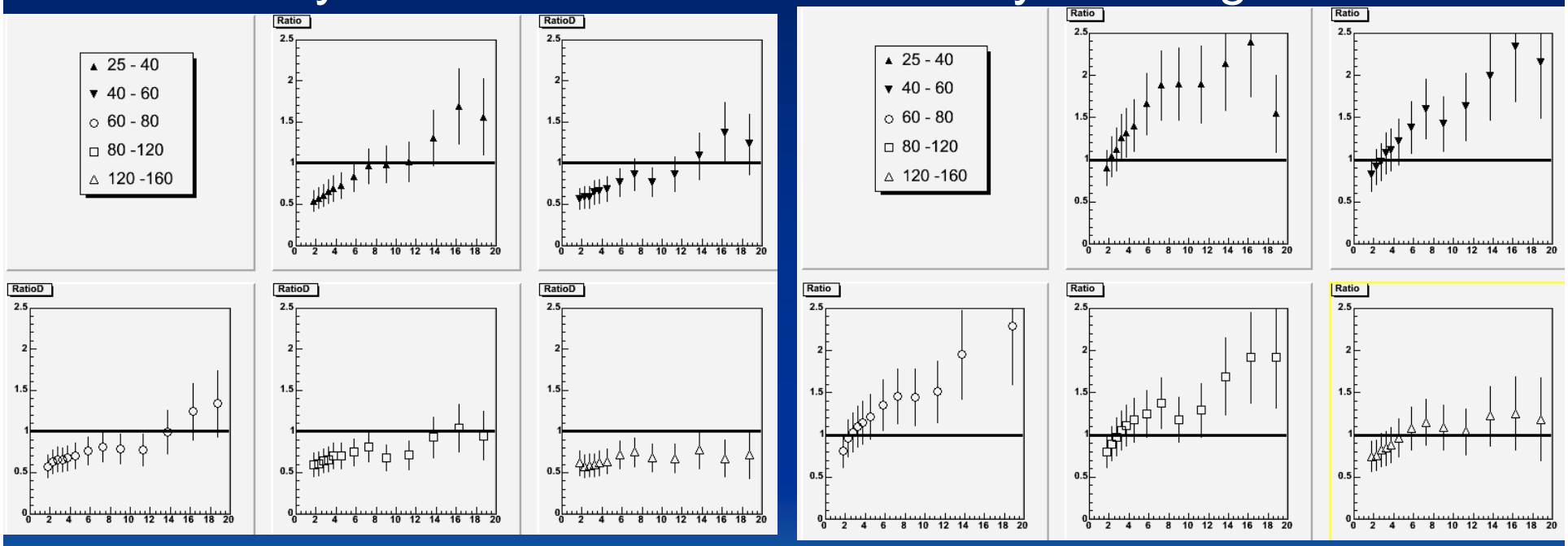
E_T range (GeV)	25-40	40-60	60-80	80-120	120-160
$p_T > 1.5$ GeV/c	$.17 \pm .018$	$.23 \pm .020$	$.26 \pm .021$	$.27 \pm .020$	$.24 \pm .018$
$p_T > 0$ GeV/c (exp)	$.21 \pm .020$	$.26 \pm .022$	$.29 \pm .022$	$.30 \pm .021$	$.27 \pm .019$
$p_T > 0$ GeV/c (power)	$.21 \pm .019$	$.27 \pm .021$	$.30 \pm .022$	$.30 \pm .021$	$.27 \pm .019$

E_T range (GeV)	25-40	40-60	60-80	80-120	120-160
$p_T > 2.5$ GeV/c	$.078 \pm .0076$	$.10 \pm .083$	$.11 \pm .0091$	$.12 \pm .0085$	$.11 \pm .0078$
$p_T > 0$ GeV/c (exp)	$.11 \pm .013$	$.14 \pm .013$	$.14 \pm .014$	$.16 \pm .012$	$.13 \pm .011$
$p_T > 0$ GeV/c (power)	$.11 \pm .0085$	$.15 \pm .0089$	$.15 \pm .010$	$.15 \pm .009$	$.14 \pm .0085$

	This Exp	LEP (90 GeV)
K_S	0.27+/-0.021	0.5+/-0.06
$\Lambda+\bar{\Lambda}$	0.15+/-0.089	0.21+/-0.006

K_S ratio : data/MC ($\Delta R<0.5$)

Pythia CDF RUNII Preliminary Herwig



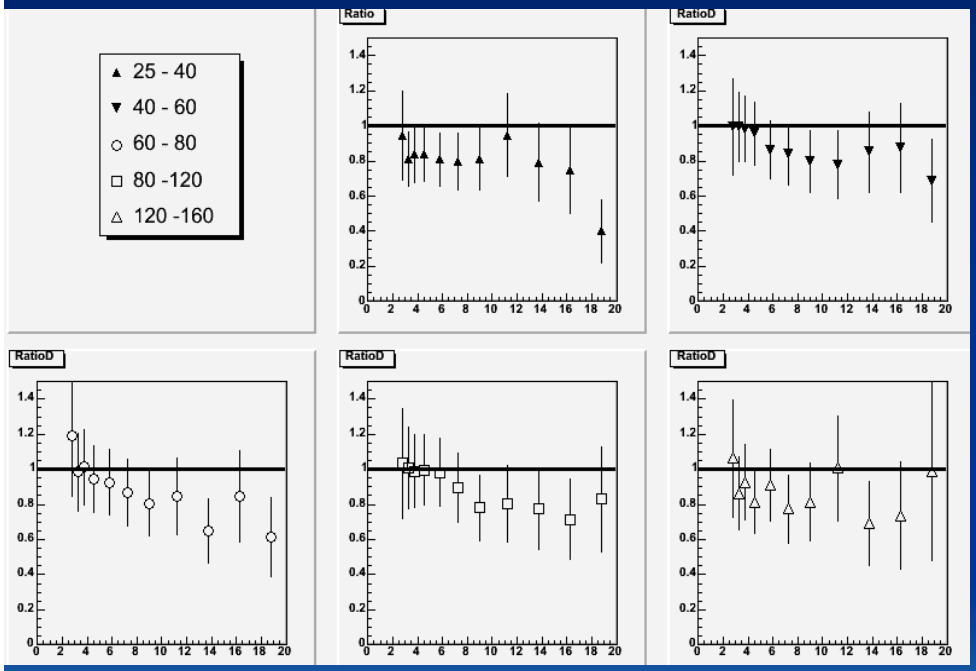
p_T (GeV/c)

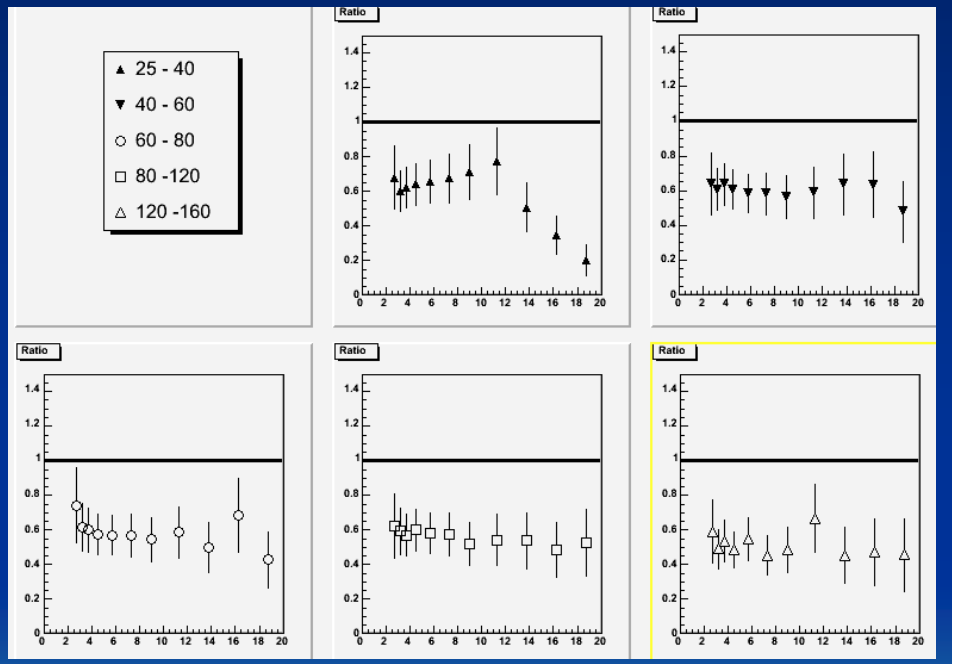
Λ ratio: data/MC ($\Delta R<0.5$)

Pythia

CDF RUNII Preliminary

Herwig





p_T (GeV/c)